CQA REPORT

CONSTRUCTION QUALITY ASSURANCE REPORT

Disposal Module 6.1 Liner System

Recology Hay Road Facility

Revision 0

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1.0 INTRODUCTION

1.1 Overview

Recology Hay Road (RHR) owns and operates the Recology Hay Road Facility. Disposal Module (DM) 6.1 is a Class II waste management unit that was constructed in accordance with the project technical specifications, construction drawings, and construction quality assurance (CQA) plan. This construction was also completed in accordance with Waste Discharge Requirements (WDRs) Order No. R5-2008-0188, and the applicable requirements of federal Subtitle D regulations and Title 27 of the California Code of Regulations (CCR). The project site location is shown on Figure 1. Golder Associates Inc. (Golder) provided the CQA services for the construction of this base liner system.

Disposal Module (DM) 6.1 was constructed in two phases. The first phase was completed during the summer of 2011 and consists of clean-closure of the former Land Treatment Area (LTU) within the DM-6 footprint and the bulk general fill placement to prepare the base liner system subgrade. The second phase was constructed during the summer of 2012 and consisted of finish grading the subgrade and installing the liner system components.

This CQA Report documents construction activities and CQA monitoring and testing for construction of the DM-6.1 subgrade and base liner system. Golder Associates Inc. (Golder) provided CQA services for both phases of the DM-6.1 construction.

1.2 Project Description

The DM-6.1 measures approximately 7.2 acres in plan area and is located immediately west of DM-5.2. DM-6.1 drains to a sump at the northern end of the landfill. Figure 2 shows the site plan and relative location of DM-6.1. Figure 3 shows the grading plan for the DM-6.1 liner system.

The DM-6.1 base grades slope at 2 percent toward three leachate collection lines oriented generally in a north-south direction. These leachate collection lines slope at 1 percent toward the northern perimeter berm. The northern perimeter berm is inclined at 2H:1V (horizontal to vertical) along the interior slope and inclined at 3H:1V along the exterior slope. The east side of the DM-6.1 primary liner system ties into the existing DM-5.2 base liner system.

The base liner system is a double-composite liner system as described in the Liner Performance Demonstration Report prepared by Golder (April 15, 2003). The base liner containment system is comprised of the following components (from the bottom up):

- General earthfill (the upper 6-inches comprise of fine-grained soils)

- Secondary 60-mil HPDE geomembrane (double-sided textured)
- Leak detection geocomposite
- 2.5-foot primary compacted clay liner ($k \leq 1 \times 10^{-7}$ cm/s, excluding the lower 6-inches)
- Primary 60-mil HPDE geomembrane (single or double-sided textured)
- 6-inch thick leachate collection and removal system (LCRS) gravel
- 8-oz. geotextile filter layer
- 1-foot thick operations layer

The side-slope liner system is a single-composite liner system. The side-slope liner containment system is comprised of the following components (from the bottom up):

- General earthfill
- Geosynthetic clay liner (GCL) with a minimum 30-mil HDPE geomembrane (geomembrane side down)
- Primary 60-mil HPDE geomembrane (single-sided textured)
- LCRS geocomposite
- 1.5-feet of operations soil

Prior to placement of the subgrade general fill, the northeast portion of the Land Treatment Unit (LTU) was clean-closed. The closure effort included relocating the admixed biosolids stockpile from the DM-6 footprint to a stockpile located over existing refuse in the DM-5 area. Following relocation of this stockpile, impacted soils underlying the stockpile and the LTU mixing area were removed and also stockpiled over existing refuse adjacent to the relocated stockpile. The depth of impacted soils was determined through sampling and laboratory testing. The concentrations of chemical constituents that characterized the impacted soil were analyzed from samples taken at one-foot depth intervals. Following removal of the impacted soils, confirmation samples were obtained from 0.5 to 1.0 feet below the remaining soil surface and tested to confirm that the remaining soil was within allowable concentrations for the chemical constituents of concern. The partial LTU clean-closure is documented by the "Land Treatment Unit Clean-Closure in Disposal Module DM-6 Footprint, Recology Hay Road, Vacaville, CA" (Golder, September 2011). A copy of this report was submitted to the Central Valley Regional Water Quality Control Board (CVRWQCB) in September 2011 and is included in Appendix C.

1.3 Contractors

Construction of the LTU Clean-Closure, the DM-6.1 subgrade, and the DM-6.1 base liner system was performed by BostonPacific Inc. (BPI) of Dixon, who acted as the general contractor. The installation subcontractor for the geosynthetic liner system was D&E Construction (D&E) of Visalia, California. The 60-mil HDPE primary geomembrane, 60-mil HDPE secondary geomembrane, and Gundseal (GCL with 30-mil geomembrane backing) material were provided by GSE, located in Houston, Texas. The geocomposite was also provided by GSE, comprised of geotextile manufactured by SKAPS Industries and geonet manufactured by GSE. The geotextile was manufactured by SKAPS Industries, located in Commerce, Georgia. The leachate extraction system was installed by Advanced Wind, Solar, Hydro Power, Inc. (Advanced Power), located in Redwood Valley, California. Surveying for the project was completed by Bellecci & Associates, Inc. under subcontract to BPI.

1.4 Construction Quality Assurance

Golder provided CQA monitoring and testing services for the DM-6.1 base liner construction project according to the CQA Plan approved by the CVRWQCB. The CQA services consisted of observing, testing, and documenting the construction activities to verify compliance with the construction drawings and specifications. The CQA services included, but were not limited to:

- Review of manufacturer's submittals and conformance testing of the geosynthetic products
- Testing of the construction materials used for the general earthfill, low-permeability soil liner, LCRS gravel, and operations soil
- Observation of the geosynthetics installation and testing of the field seams for the HDPE geomembrane
- Observation of the LCRS collection piping, sump riser pipes, leachate extraction system, and the power supply shed installations

During the subgrade construction, Golder provided on-site CQA technicians and CQA oversight from August 3, 2011 until October 20, 2011. Debra Carroll provided lead CQA construction observation and field testing for the DM-6.1 subgrade in 2011. During the base liner system construction, Mr. Richard Siemaszkiewicz provided the lead CQA observation and testing in the field for the base liner system for DM-6.1 from May 7, 2012 until July 28, 2012. Mr. Jesse Smith, Mr. Ken Brown, and Ms. Lindsey Davison provided technician support throughout the 2012 DM-6.1 base liner system project. Mr. Pete Bowers, P.E., provided project supervision and was the CQA Engineer-of-Record.

Photographs documenting key components and activities of the construction process were taken on a regular basis. Selected photographs are included in Appendix A.

Daily field monitoring reports were prepared throughout the construction to document the construction and the CQA observation and testing. The field monitoring reports are included in Appendix B.

1.5 Project Documents

All work for the DM-6.1 base liner system was performed according to the construction drawings and specifications, which are listed below:

- "Construction Drawings, Recology Hay Road, Disposal Module 6, Base Liner Subgrade, Solano County, California," prepared by Golder Associates, dated May 2011
- "Construction Specifications, Disposal Module 6 Subgrade, Recology Hay Road, Vacaville, California," prepared by Golder Associates, dated June 2011
- "Construction Quality Assurance Plan, Disposal Module 6 Subgrade, Recology Hay Road Landfill, Vacaville, California," prepared by Golder Associates, dated June 2011
- "Construction Drawings, Recology Hay Road, Disposal Modules 6.1, Base Liner System, Solano County, California," prepared by Golder Associates, dated March 2012
- "Construction Specifications, Disposal Modules 6.1 Base Liner System, Recology Hay Road, Vacaville, California," prepared by Golder Associates, dated March 2012
- "Construction Quality Assurance Plan, Disposal Modules 6.1 Liner System, Recology Hay Road Landfill, Vacaville, California," prepared by Golder Associates, dated March 2012

1.6 Design Changes and Clarifications

Generally during the course a project, design changes and/or clarifications are processed to facilitate the construction process. During the construction of the DM-6 subgrade, one design change was required as follows:

- Recology elected to reduce the footprint of the landfill module to be constructed at this time. The southern limit of the DM-6 footprint was moved approximately 390 feet to the north. This effectively divides DM-6 into DM-6.1 (northern module) and DM-6.2 (southern module). The adjusted DM-6 subgrade area, now DM-6.1, is approximately 7.2 acres, a reduction of 4.2 acres from the Construction Drawings. DM-6.2 will be constructed in the future.

1.7 Surveying and Preparation of Record Drawings

Bellecci & Associates, Inc., under the supervision of Charles N. Capp, registered land surveyor, performed surveying for the project. Bellecci & Associates, Inc. established control points in the field for use by the contractor. Based on the control points, BPI performed construction grade control using Global Positioning System (GPS) technology. Bellecci & Associates, Inc. completed as-built surveys using the 50-foot grid system presented in the Drawings to determine the as-built elevations of each layer. As-built surveys were completed for the following:

- Top of general earthfill (subgrade)
- Top of low-permeability soil liner
- Top of LCRS gravel
- Top of operations soil

The record drawings prepared by Bellecci & Associates, Inc. are presented in Appendix D.

The location of each HDPE geomembrane panel was determined in the field using a measuring wheel. The record drawings for the HDPE geomembrane panels (primary and secondary layers) were prepared by D&E and reviewed by Golder. These drawings are also presented in Appendix D.

2.0 SUBGRADE PREPARATION AND GENERAL EARTHFILL

The subgrade preparation required for the construction of the DM-6.1 base liner system consisted of placing compacted general earthfill to the lines, grades and tolerances specified in the construction drawings. Approximately 143,500 cubic yards (cy) of general earthfill was excavated from the site borrow area and then used as general fill for base grades associated with DM-6.1. The borrow soils predominately consist of clays and silty clays with occurrences of interbedded clayey sand and occasional pockets of fine- to medium-grained sand.

General earthfill placement began on August 15, 2011. The general earthfill was excavated using a Komatsu PC600LC excavator and hauled to DM-6 using off-road end-dump trucks. Excavation occurred from the soil borrow area located west of the landfill. Standing water in the borrow area was pumped out beginning in early August. BPI excavated dewatering trenches in the borrow area following mobilization in August. In general, the soils were excavated at relatively high moisture contents. Moisture conditioning to dry the soils was completed by placing the soils in thin lifts and performing compaction the following day. Compaction was performed with a REX 350 pad-foot compactor. General earthfill placement for the cell subgrade was completed on October 20, 2011. Additional general earthfill placement occurred at the start of the liner system construction in May 2012 to backfill a drainage trench left in-place over the winter months. This additional general earthfill was estimated to be approximately 400 cy.

CQA procedures for the general earthfill consisted of laboratory testing, monitoring placement methods, moisture conditioning, and determination of compaction using nuclear moisture-density testing methods (ASTM D6938). Laboratory testing of the general earthfill material consisted of Proctor compaction tests (ASTM D1557). Appendix E.1 includes the proctor compaction curves for the general earthfill. A summary of the in-situ density testing is presented in Appendix E.2. A total of 362 compaction tests were performed on an estimated 143,535 cy of soil, resulting in a testing frequency of 396 cy/test. This frequency exceeds the required testing frequency identified in the CQA Plan (1 test per 500 cy). The results of the compaction tests each measured a relative compaction of at least 90 percent. The project specifications required a minimum relative compaction of 90 percent in accordance with ASTM D 1557. Therefore, the compaction test results indicated that the general earthfill was placed and compacted in accordance with the project specifications.

The general earthfill material was compacted to provide a firm and unyielding surface to support the liner system. At the completion of the placement and compaction, the exposed soils at the surface were systematically examined by Golder's CQA Technician to verify that the upper surface of the liner subgrade consisted of clay, silty clay, and/or sandy clay classified as CH, CL, or SC in accordance with the Unified Soil Classification System.

A topographic survey was prepared by Bellecci & Associates, Inc. Point data was also submitted and verified by Golder for compliance with the design grading tolerances. The survey elevations are indicated on the as-built topographic drawing, presented in Appendix D.

3.0 LOW-PERMEABILITY SOIL LINER

3.1 General

The low-permeability soil material was obtained from on-site clay soils contained in the borrow area located west of the landfill. Golder completed a borrow investigation on January 17, 2012. Soil obtained for placement as low-permeability soil liner was obtained from the horizontal and vertical range of the area investigated. Laboratory tests were performed on selected samples to verify suitability of the on-site soil for use as a low-permeability soil liner material. A test pad and field infiltration test was completed during the 2012 construction of DM-6.1 to verify that the proposed equipment and handling procedures would result in low-permeability soil liner that met the compaction and permeability requirements.

3.2 Test Pad Construction and Field Infiltration Measurement

3.2.1 Test Pad Construction

A test pad was constructed from May 7, 2012 through May 8, 2012 to establish placement and compaction procedures for the new low-permeability soil liner material used for the primary liner. The test pad was constructed in an area measuring approximately 30 feet by 40 feet located in the borrow area. The test pad consisted of four 6-inch thick compacted lifts.

The borrow soils were moisture conditioned in the borrow area using a water truck. The soils were excavated using a Kamatsu PC600LC excavator and placed directly on the test pad area. The soils were placed and compacted in 6-inch thick lifts using a Caterpillar 815B pad-foot compactor.

Samples of the low-permeability soil liner were obtained on each lift and laboratory testing completed to measure moisture content (ASTM D2216), particle-size distribution (ASTM D1140), Atterberg Limits (ASTM D4318), modified Proctor density (ASTM D1557), and hydraulic conductivity (ASTM D5084). The results of this testing are summarized in Table F.1 (Appendix F).

Compaction testing on the test pad was completed using a nuclear density gauge (ASTM D6938). The results of this testing are included in Table F.2.

3.2.2 Evaluation of In-Situ Permeability

In-situ permeability was evaluated by obtaining four relatively undisturbed Shelby-tube samples of the completed test pad soils for laboratory permeability testing. In addition, a two-stage borehole infiltration test, referred to as the Boutwell Permeameter, was performed following completion of the test pad. The Boutwell Permeameter test consisted of initially installing six borehole permeameters measuring 4-inches in diameter. Three permeameters were installed on each side of the test pad measuring approximately 10 to 15 feet apart. A sealed, control permeameter was installed in the center of the test permeameter layout. The purpose of the control permeameter was to allow correction for temperature and atmospheric pressure impacts.

Measurements of one of the Boutwells (BW-3) were discontinued due to it's close proximity to the edge of the test pad.

Completion of the field infiltration test using the Boutwell Permeameter can involve one or two stages. The first stage involves placement of the permeameter flush with the bottom of the test hole such that infiltration occurs through the bottom of the borehole. At the end of this first stage, an upper-bound vertical permeability value is calculated by conservatively assuming that infiltration occurs vertically through the bottom of the test hole. This permeability is a conservative upper-bound value because the infiltration rate actually involves some radial flow from the bottom of the permeameter. Therefore, the true vertical permeability is less than this upper-bound value. In many cases, the field infiltration is halted at the end of the first stage if the upper bound permeability value is less than the permeability specification requirement.

For this project, Stage 2 tests were completed, although the result of the Stage 1 tests indicated passing permeability values. The second stage of the test involved advancing the test hole below the base of the permeameter and then resuming measurement of the infiltration rate. The second stage primarily measures horizontal permeability, although there is a vertical and radial component of flow. By assuming that flow is only horizontal, the second stage measures an upper-bound horizontal permeability. After calculating the upper bound vertical and horizontal permeability values, the true vertical and horizontal permeabilities can be determined using the equations developed by Boutwell (Trautwein and Boutwell, 1994) if the soils are homogeneous.

For the DM-6.1 base liner project, the results from the first stage measured an average upper-bound permeability of 9×10^{-8} cm/s, which is below the specification requirement of 1×10^{-7} cm/s. The results of the second stage indicated an upper bound horizontal permeability of 8×10^{-8} cm/s or less. From these upper-bound values, a true average vertical permeability of 9×10^{-8} cm/s was calculated.

The four laboratory permeability tests for the test pad soil samples measured permeability values ranging from 1.2×10^{-8} cm/s to 3.7×10^{-8} cm/s with an average permeability of 2.4×10^{-8} cm/s.

For the past eight disposal module construction projects at the Recology Hay Road Facility, the compaction window has been defined by a minimum degree of saturation of 80 to 85 percent, a minimum relative compaction of 90 percent, and a moisture content of 17 to 22 percent. Historically, the measured maximum dry densities have been around 118 pcf, resulting in a minimum dry density requirement of 106 pcf. For the DM-6.1 test pad, we measured an average dry density of 106.9 pcf and a minimum dry density of 106.1 pcf, resulting in a minimum compaction of 90.0% based on a maximum dry density of 117.9 pcf. The compaction achieved for the test pad exceeds 106 pcf. The placement window is identical to that used during the previous construction event and is shown in Appendix F.1.

The results of the field and permeability tests indicate that the borrow materials are capable of being placed and compacted to achieve a permeability of less than 1 x 10^{-7} cm/s if the minimum dry density is 106 pcf or greater.

3.3 Low-Permeability Soil Liner Construction

The low-permeability soil liner is a 2.5-foot thick layer of compacted low-permeability soil in which the upper two feet is required to have a permeability of 1 x 10^{-7} cm/s or less. The soils used to construct this layer were obtained from the borrow area located west of the landfill. The low-permeability soil liner was constructed from May 31, 2012 through June 18, 2012.

The low-permeability soil consisted of a brown, silty clay classified as a CH or CL in accordance with the Uniform Soil Classification Systems (USCS) per ASTM D2487. The soils exhibited an average Liquid Limit (LL) of 41, an average Plastic Index (PI) of 28 and average fines content (minus No. 200 sieve) of 80 percent. These values are very similar to those used in the previous DM-3.2/3.3 liner construction.

The low-permeability soil liner was constructed directly on top of the leak detection geocomposite. The first lift measured 12-inches in thickness to prevent construction damage to the underlying geosynthetic layers. The lower 6-inches of the first lift was placed as a foundation layer for the overlying 2-feet of low-permeability soil liner. Although the foundation layer was not tested for compaction or permeability, it was tested for Atterberg Limits and grain-size properties to establish that the material is the same as that used for the soil liner. The quantity of foundation layer material was estimated at 5,440 cy and the low-permeability soil liner was estimated at 21,760 cy, for a combined total of 27,200 cy.

The low-permeability soil liner material was excavated from the borrow area at moisture contents generally within the specified compaction window. Moisture was maintained in the placement area using a water truck or conditioned as necessary. The soil was excavated with a Kamatsu PC600LC excavator and hauled to DM-6.1 using off-road end-dump trucks. Following the initial 12-in lift, the soils were placed in 6 to 8-inch thick loose lifts and compacted with a Caterpillar 815B pad-foot compactor. Final grading was completed using a Caterpillar 140G grader.

The compaction window consisted of the same window used previously for the DM-3.2/3.3 base liner construction. This compaction window was defined by a minimum moisture content of 17 percent, a minimum relative compaction of 90 percent, and a minimum degree of saturation of 83 percent.

CQA procedures consisted of monitoring placement, moisture conditioning, and measurement of in-situ moisture-density using a nuclear density gauge (ASTM D6938) and the drive cylinder method (ASTM D2937). Golder performed 112 nuclear moisture-density tests, resulting in a testing frequency of one test per 194 cy. This frequency meets the CQA Plan requirements (maximum 250 cy/test). In addition, samples of the low-permeability soils were obtained for laboratory testing including moisture content (ASTM D2216), particle-size distribution (ASTM D1140), Atterberg Limits (ASTM D4318), modified Proctor density (ASTM D1557), and hydraulic conductivity (ASTM D5084). The results of this testing are summarized in Appendix G.1. A summary of the in-situ moisture density testing is presented in Appendix G.2. CQA testing frequencies are summarized in Table 1.

TABLE 1
LOW-PERMEABILITY SOIL LINER CQA TESTING FREQUENCIES

Parameter	Test Method	Minimum Specified Frequency	Number of Tests	Actual Construction Frequency
Moisture-Density	D1557	1 Per 5,000 or change in material	6	1 Per 4,533 CY
Nuclear Moisture-Density	D6938	1 Per 250 CY	112	1 Per 194 CY
Moisture Content	D2216/D4643	1 Per 1,500 CY	19	1 Per 1,432 CY
Sand Cone, or Drive Cylinder	D1556, D2937	1 Per 20 Nuclear Density Tests	6	1 Per 19 tests
Particle Size	D422/D1140	1 Per 1,500 CY	19	1 Per 1,432 CY
Atterberg Limits	D4318	1 Per 1,500 CY	19	1 Per 1,432 CY
Soil Classification	D2487/2488	1 Per 1,500 CY	19	1 Per 1,432 CY
Laboratory Hydraulic Conductivity on Field Collected Sample	D5084 at 15 psi	1 Per 1,500 CY	16	1 Per 1,360 CY

On average, the soils were compacted to a dry density of 109.1 pcf and a moisture content of 18.3%.

Permeability samples were obtained in 3-inch diameter Shelby tubes and transported to Sierra Testing Laboratories in El Dorado Hills, California. The results of the permeability testing indicated measured permeabilities ranged from 2.0×10^{-9} cm/s to 6.8×10^{-8} cm/s with an average of 2.3×10^{-8} cm/s.

The top of the primary low-permeability soil liner was surveyed to verify that the design thickness and grades were achieved. The as-built plan is included in Appendix D.

The results of the CQA observations, field and laboratory testing, and surveying indicate that the primary low-permeability soil liner material was placed in compliance with the project specifications.

4.0 LCRS, LEAK DETECTION, AND LYSIMETER GRAVELS

The leachate collection and recovery system (LCRS) consists of a 0.5-foot thick layer of 3/8-inch pea gravel spread across the floor of the cell over the 60-mil HDPE primary geomembrane. The LCRS gravel materials were also placed in the lysimeter and leak detection sumps. Additionally, LCRS collection pipes were installed on the floor at the locations shown on the Drawings. BPI began welding LCRS collection pipe on June 14, 2012 and placed LCRS gravel between June 21, 2012 and July 2, 2012. HDPE piping materials were obtained from ISCO Industries.

The LCRS gravel was supplied by Cemex located in Madison, California. Approximately 5,580 cy of gravel was hauled to the site in transfer dump trucks. Placement began at the south end of DM-6.1 and was placed northward. Placement was performed by pushing out gravel in 3 to 5 foot thick "roads" with a D8N dozer from the leading edge of operations layer. The roads were placed above the LCRS collection pipe then spread into a 6-inch thick lift. BPI spread and graded the LCRS gravel using a Caterpillar D6 low-ground pressure (LGP) dozer operating on a base of approximately 6-inches of gravel. The dozer used global positioning system (GPS) guided survey equipment to provide grade control. As segments of the LCRS gravel layer were completed, 8 oz/sy nonwoven geotextile was deployed over the gravel. Water was then sprayed over the gravel as the LCRS layer was covered with operations layer materials.

Samples were obtained from the gravel that was delivered to the site. The samples were tested for grain-size (ASTM D422), fractured faces (ASTM D5821), and permeability (ASTM D2434). The measured permeability exceeded the minimum requirement of 1.0 cm/s and averaged 2.6 cm/s. The gravel generally met the maximum particle-size requirement (100 percent less than 1/2-inch minus, 100 to 85 percent less than the 3/8-inch sieve, 0 to 30 percent less than the U.S. No. 4 sieve, and 0 to 2 percent less than the U.S. No. 200 sieve). The fraction finer than the No. 4 sieve slightly exceeded the specification value of 0 – 30 percent in four of the six samples tested. However, this material was accepted since the permeability values were greater than two times the minimum permeability requirement. The percentage of particles 3/8-inch or larger with more than one fractured face was measured between 4 and 7 percent, which was less than the 25 percent maximum value.

The CQA testing frequencies met or exceeded the CQA plan requirements and are detailed in Table 2.

TABLE 2

LCRS GRAVEL CQA TESTING FREQUENCIES

Parameter	Test Method	Minimum Specified Frequency	Number of Tests	Actual Construction Frequency
Sieve Analysis	D422/C136	1 Test Per 1,500 CY	6	1 Per 930 CY
Visual Classification	D2488	Continuous Observation		Continuous Observation
Hydraulic Conductivity	D2434	1 Test Per 3,000 CY	3	1 Per 1,860 CY
Fractured Faces (Gravel Fraction Only)	D5821	1 Per Source[1] 1 Test Per 1,500 CY	6	1 Per 930 CY

Based on the survey data submitted by BPI, the thickness of the LCRS gravel was averaged 0.53 feet thick and was within design tolerances.

Two 2-inch diameter HDPE injection pipes were installed within the DM-6.1 LCRS gravel. A permanent injection pipe was installed from the top of the northern perimeter levee approximately 50 feet east of the west edge of DM-6.1 and capped at the southern edge of DM-6.1. This permanent injection pipe will be extended for use in DM-6.2 during future construction. A temporary injection pipe was installed from the south edge of DM-6.1 extending approximately 200 feet northward and perforated along the northern 100 feet. The temporary injection pipe will be abandoned following the future construction of DM-6.2. The purpose of the injection pipes is to allow water to be injected annually into the LCRS to verify adequate performance.

5.0 GEOSYNTHETICS

5.1 Review of Submittals and Material Conformance Testing

Geosynthetics utilized for the DM-6.1 base liner construction project consisted of the following components:

- 60-mil double-sided textured HDPE geomembrane liner (black both sides)
- 60-mil single-sided textured HDPE geomembrane liner (white/black)
- Geocomposite drainage layer
- 8-oz. geotextile filter layer
- Geosynthetic clay liner (GCL) bonded with a 30-mil or 40-mil HDPE geomembrane backing sheet

Golder performed conformance testing of the HDPE geomembrane, geocomposite, geotextile, and GCL materials and reviewed the manufacturer's quality control certificates prior to use of the materials on the project. Copies of the manufacturer's quality control documentation are included in Appendix I as follows:

- Appendix I.1 – HDPE Geomembrane
- Appendix I.2 – Geocomposite
- Appendix I.3 – Geotextile
- Appendix I.4 – Geosynthetic Clay Liner

Conformance samples were obtained from the manufacturing plant or upon delivery to the site. Golder staff selected the rolls of materials for conformance sampling. Samples were shipped to Golder's Geosynthetics Laboratory in Atlanta, Georgia for conformance testing. Copies of the conformance tests results and test summaries are presented in Appendix J as follows:

- Appendix J.1 – HDPE Geomembrane
- Appendix J.2 – Geocomposite
- Appendix J.3 – Geotextile
- Appendix J.4 – Geosynthetic Clay Liner

Golder's technicians performed an inventory of the on-site materials to confirm that the roll numbers for each of the geosynthetic components correlated to the manufacturer's submittals and shipping manifests. Copies of the material inventories prepared by Golder are presented in Appendix K as follows:

- Appendix K.1 – HDPE Geomembrane
- Appendix K.2 – Geocomposite
- Appendix K.3 – Geotextile
- Appendix K.4 – Geosynthetic Clay Liner

The frequencies of conformance testing met or exceeded minimum frequencies specified in the CQA Plan, which are summarized below:

- HDPE Geomembrane: 8 tests for 606,000 square feet (min. required frequency of 1 test/150,000 sf required)
- Geocomposite: 2 tests for 308,000 square feet (min. of 1 test/250,000 sf required)
- Geotextile: 3 tests for 297,000 square feet (min. of 1 test/150,000 sf required)
- Geosynthetic Clay Liner: 3 tests for 19,000 square feet (min. of 1 test/150,000 sf required)

In addition, direct shear testing was completed between the geomembrane/geocomposite (GM/GC) and geomembrane/low-permeability soil liner (GM/Soil) interfaces. The results of these tests are included in Appendix J.1. The test results indicated that the measured shear strength for GM/GC interface was slightly below the minimum project specification requirement. To determine whether the conformance test results should be accepted or rejected, Golder completed a slope stability analysis along the north side of DM-6.1 using the actual measured shear strengths for the GM/GC interface. The factors of safety under static and seismic conditions exceed minimum design requirements; therefore, the results were accepted. Details on our analysis are presented in Appendix J.1.

Based upon the manufacturer's quality control documentation and the results of the conformance tests, all of the geosynthetic materials that were installed were accepted. Twenty-two rolls of the 60-mil geomembrane were rejected and removed prior to delivery due to non-conformance with the thickness specification. This material was replaced with new material that passed conformance testing.

5.2 Geomembrane

A 60-mil double-sided textured, HDPE, geomembrane liner (colored black on both sides) was installed as the DM-6.1 secondary liner system and in the pan lysimeter to the limits identified on the design drawings. A 60-mil single-sided textured, HDPE geomembrane liner (colored white on the smooth side) was installed as the DM-6.1 primary liner system with the textured side down. The HDPE geomembrane was deployed following the completion of the grading and surveying of the low-permeability soil liner. Prior to geomembrane deployment, the subgrade was inspected to verify that it was suitable to support the geomembrane liners. Copies of the subgrade certificates are included in Appendix L.1.

The pan lysimeter and secondary HDPE geomembrane deployment began on May 21, 2012. The secondary geomembrane liner was completed on June 1, 2012. The primary HDPE geomembrane deployment began on June 19, 2012 and was completed on June 27, 2012.

The 60-mil HDPE geomembrane was deployed using an all-terrain forklift and a spreader bar. Each roll measured 22.5 feet wide by 490 feet long for the double-sided textured, and 22.5 feet wide by 540 feet long for the single-sided textured. A record of the deployment logs is presented in Appendix L.2. The record drawings representing the location of the liner panels were prepared by D&E and reviewed by Golder. These as-built record panel drawings are presented in Appendix D.

Golder observed the deployment and seaming of the 60-mil HDPE geomembrane installed by D&E. Prior to seaming operations, D&E performed trial seams at the beginning of each shift, or upon re-starting the machine after lunch breaks, to demonstrate the adequacy of the seaming apparatus and the operator's procedures. Each trial seam was sampled and tested by D&E for peel adhesion and bonded seam strength. These trial seaming procedures were observed and documented by Golder personnel. Upon observation of successful trial welds, the operators were given approval to begin seaming. Archive samples of trial welds were collected. Copies of the trial seam logs are presented in Appendix L.3.

In general, the split wedge fusion method was used for seaming of the HDPE geomembrane liner and ran concurrently with deployment of the geomembrane. This method of fusion seaming produces an air channel that is air-pressure tested for leaks. The extrusion seaming method was utilized for patches, small repairs, and the tie-in to the DM-5.2 liner system. Golder observed and documented the welding of all seams, patches, or other repairs either during or shortly after completion. Copies of the seaming logs are presented in Appendix L.4.

All non-destructive seam continuity testing was performed by D&E and observed by Golder. Non-destructive seam testing was required on all field seams and on all repairs including the destructive test sample patches. Two methods of non-destructive testing were used for this project:

- Vacuum testing on extrusion welds
- Air pressure testing on split wedge fusion welds

A vacuum box is a rigid-wall box with a clear Plexiglas top and a neoprene gasket around the bottom of the box forming a seal between the box and the HDPE liner. Vacuum testing procedures consist of the following:

- Applying a soapy water solution to the seam
- Applying a vacuum of approximately 10 inches of mercury (5 psi) to the inside of the box for 10 seconds
- Observing the weld for expanding bubbles which would indicate a discontinuity in the weld

Air pressure testing procedures consist of the following:

- Sealing off the air channel between the inside and outside tracks of the fusion weld at each end of the seam
- Inserting a needle with an attached pressure gauge into the air channel
- Inflating the air channel to approximately 35 psi using a small pressurized air tank

- Observing the pressure gauge over a five-minute period (a pressure drop of more than 2 psi during this period would indicate a possible discontinuity in the seam)
- Puncturing of the seam air channel at the far end of the seam to allow release of the pressurized air to verify testing was for the entire seam length

Any leaks or discontinuities detected in the seams or welds were marked and subsequently repaired in accordance with the specifications. As repairs were made to the geomembrane, Golder documented the location and verified that all repairs were vacuum box tested. Documentation summarizing the observation of the non-destructive seam testing is presented in Appendix L.5.

Repairs consisted of small patches, extrusion beads, or welds. Repairs were made along the intersection of panels, at cuts in the liner made for air pressure testing of the fusion welded seams, or for defects due to holes or blemishes observed in the liner from installation damage. The repairs were marked in the field by Golder and were then subsequently repaired by D&E. A summary of the Repair Logs is presented in Appendix L.6.

A summary of the destructive test results is presented in Appendix L.7. In the destructive test, ten (10) one-inch wide test coupons are cut from each destructive test sample. Five of the coupons are tested for adhesion (peel test mode, both inside and outside track for fusion seams) and five coupons are tested for bonded seam strength (shear test mode) in accordance with ASTM D6392. Breaks are analyzed for Film-Tear-Bond (FTB) or non-FTB in accordance with ASTM D6392.

Destructive test samples were obtained from the HDPE geomembrane seams at a maximum frequency of one sample per 500 lineal feet. A total of 69 destructive test samples were tested, resulting in an overall testing frequency of approximately one test per 469 feet of seam.

Test results indicated that all of the destructive seam tests met the project specifications.

5.3 Geocomposite

A geocomposite drainage layer was installed directly over the secondary 60-mil HDPE geomembrane liner as the leak detection layer on the floor of the landfill. In addition, a geocomposite drainage layer was installed over the primary 60-mil HDPE geomembrane layer on the side-slope as part of the LCRS.

The geonet component of the geocomposite layers was installed with a minimum 4-inch overlap between adjacent panel edges and fastened using plastic ties at a maximum spacing of 5 feet on panel edges and 1-foot across butt-seams. No butt-seams were placed on the slopes. The upper geotextile component was sewn continuously along seams in accordance with the project specifications.

Based on observations made by Golder, the geocomposite layers were installed in accordance with the project specifications.

5.4 Geotextile

An 8-oz/sy non-woven geotextile was installed as a filter layer above the LCRS gravel. D&E installed the geotextile above the LCRS gravel immediately following the placement and grading of the LCRS gravel layer.

The geotextile panels were seamed together with sewing equipment using polymeric thread. Golder verified that adequate seaming was performed and observed the general condition of the geotextile.

5.5 Geosynthetic Clay Liner

A Gundseal geosynthetic clay liner (GCL) was installed on the north perimeter levee slope. Gundseal is a composite geosynthetic comprised of a bentonite layer bonded to a 30-mil or 40-mil HDPE geomembrane. Five rolls of Gundseal with 30-mil geomembrane backing and five rolls of Gundseal with 40-mil geomembrane backing were procured for the project. The Gundseal material was installed geomembrane side down on the perimeter levee slope subgrade surface, which measures 19,000 sf in area, beneath the primary geomembrane. The quality control certificates for this material are included in Appendices I.4. The conformance tests are included in Appendix J.4.

The installation of the GCL was started on May 21, 2012 and complete on May 24, 2012. The secondary 60-mil HDPE geomembrane was placed immediately following the GCL to protect the GCL from hydration. The GCL was deployed using an all-terrain forklift and a spreader bar. Prior to deployment, the subgrade was inspected by Golder and D&E to verify compliance with the project specifications, subgrade acceptance certificates are presented in Appendix L.1. The primary 60-mil HDPE geomembrane was placed as soon as reasonably possible following the GCL installation to protect the GCL from hydration.

6.0 OPERATIONS SOILS

The operations layer soils were placed upon completion of the LCRS gravel, geotextile filter deployment, and LCRS geocomposite drainage layer installation. The operations soil layer consisted of native borrow soils and an admixture of biosolids and soil, which were placed in specific areas delineated on the construction drawings. BPI used a Kamatsu PC600LC excavator with off-road dump trucks to deliver the operations soils from stockpiles adjacent to the cell and spread the operations layer soils with a Caterpillar D6 LGP dozer outfitted with a GPS grade control system. To address odor control issues, a thin layer (approximately 1 inch) of onsite borrow soil was spread over the admixed biosolid material. A grader was used to finish-grade the final operations soil layer surface.

Golder monitored the operations layer soil materials and the soil thickness by observing placement operations and thickness throughout the placement activities. Particle-size distribution tests and moisture content test results completed on the operations soil layer are included in Appendix M.

The placement of the operations layer was started on June 25, 2012. The operations layer and landfill composite liner system was substantially completed on July 10, 2012 with the exception of the outer edges of the liner system. The outer edges of the HDPE geomembrane were left exposed during the completion of the electrical leak location survey as discussed in Section 7. Following the completion of the electrical leak location surveys, the contractor finished placing the remaining operations soil layer materials between July 19th and 25th, 2012.

The as-built plan prepared by Bellecci & Associates, Inc. is presented in Appendix D. Review of the as-built information indicates that the operations layer was constructed in general accordance with the design grades.

7.0 LEAK LOCATION SURVEY

An electrical leak location survey (ELLS) was performed in accordance with ASTM D7007 at the completion of the operations soil layer placement. The ELLS was performed by Applied Soil and Water Technologies, LLC (ASW) under subcontract to Golder to determine if holes or defects existed in the primary 60-mil HDPE geomembrane liner following completion of the LCRS gravel and operations layer. ASW performed the ELLS from July 12 through July 13, 2012.

At the beginning of each survey, an artificial leak test was completed by placing a 1/4-inch diameter electrode at the top of the primary geomembrane to verify that the overlying gravels and operations soil could adequately conduct an electrical current. The results of the artificial leak test indicated that overlying materials were adequately conducting an electrical current.

The results of the first survey did not detect any defects in the primary HDPE geomembrane in DM-6.1. The two small perforations in the NW and SE corners of the liner system, where the DC voltage wires for the ELLS electrodes penetrated the geomembrane, were repaired on July 20, 2012. BPI completed a trial weld prior to the start of the repairs. The holes were extrusion welded and then vacuum tested. Golder was on-site, observed, and recorded the repairs. Appendix N includes a report from ASW that describes the methodology and results of the survey.

8.0 LEACHATE EXTRACTION AND GAS COLLECTION SYSTEMS

Following the construction of the base liner system, the leachate extraction system was installed. The leachate extraction system was installed by Advanced Wind, Solar, Hydro Power, Inc. (Advanced Power), Redwood Valley, California.

The leachate extraction system consists of two Grundfos submersible pumps, installed in the DM-6.1 LCRS riser pipe and in the DM-6.1 LDS riser pipe. These pumps are automatically controlled by a sump level detection system. The LCRS extraction pump also incorporates an automatic shutoff from a level detector in the leachate storage tank. Custom flange adaptors were installed on the tops of the riser pipes to provide connection ports for hoses, sampling, and level detection equipment. For each sump, a hose is provided between the LDS pump and the LCRS riser pipe to remove liquids from the LDS sump to the LCRS sump. This pipe can be switched from the LDS riser pipe flange to the lysimeter riser pipe flange as necessary if pumping is required from the lysimeter sump. A leachate conveyance pipe for the DM-6.1 sump is extended from the LCRS pump to a leachate storage tank located on the west side of Waste Pile 9 (WP-9). This pipe extends above-ground around the north side of the landfill perimeter. The pumps are powered from a bank of batteries housed in the control shed located adjacent to the riser pipes. The batteries are charged from a bank of solar panels located on the shed roof. As an alternate power source, a Honda 5000 generator is also housed in the shed.

A port was installed for future connection to the gas collection system in the LCRS riser pipe. This port consists of a 2-inch diameter HDPE stub out pipe welded to the pipe side near the top of the riser pipes.

9.0 LEAK DETECTION MONITORING CONSIDERATIONS

Water will enter the leak detection system as the liner system is loaded with refuse and the primary low-permeability soil layer consolidates. This is a common occurrence in double-liner systems containing compacted clay liners. This consolidation water is not indicative of a leak in the primary liner system.

The consolidation will generally increase as the refuse loading increases and will significantly decrease after the refuse loading remains constant. Therefore, the occurrence of consolidation water should correlate to increasing refuse loading in the waste cell.

10.0 SUMMARY AND CONCLUSIONS

Golder provided CQA and testing services during construction of the Disposal Modules 6.1 base liner system at the Recology Hay Road facility in Vacaville, California. Construction of the base liner system covered by this CQA Report occurred between August 3, 2011 and July 27, 2012.

The CQA services provided for this project consisted of observing, testing, and documenting the construction activities to verify compliance with the project design plans and specifications. The CQA activities described in this report include the following:

1. Observation and testing the general earthfill soils beneath the liner systems
2. Observation of the liner subgrade
3. Observation of the lysimeter and leak detection systems
4. Observation and testing of the low-permeability soil liner
5. Observation and testing of the geomembrane, geocomposite, geotextile, and GCL materials
6. Observation and testing of the LCRS gravel and operations soils construction
7. Completion of an ELLS
8. Review and verification of the containment system as-built documents

Based on the daily communications with CQA technicians, on observations made during site visits, and on review of the laboratory and field test results and documentation provided and certified by others, Golder hereby states that, in our professional opinion, the containment system for the DM-6.1 base liner system at the Recology Hay Road Facility was constructed in accordance with the project plans and specifications, WDR Order No. R5-2008-0188, and the applicable requirements of the California Code of Regulations, Title 27 pertaining to a Class II Landfill.

Respectfully submitted,

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